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SPACE SHUTTLE ENGINEERING AND OPERATIONS SUPPORT

DESIGN NOTE NO. D0410-008

TWO-IMU FDI PERFORMANCE OF THE SEQUENTIAL  
PROBABILITY RATIO TEST DURING SHUTTLE ENTRY

MISSION PLANNING, MISSION ANALYSIS AND SOFTWARE FORMULATION

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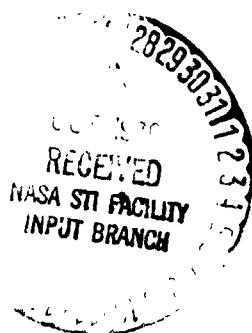
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(NASA-CR-151014) TWO-IMU FDI PERFORMANCE OF  
THE SEQUENTIAL PROBABILITY RATIO TEST DURING  
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## 1.0 SUMMARY

This design note presents 2-IMU FDI performance data for the sequential probability ratio test (SPRT) during shuttle entry. Also included are current modelling constants and failure thresholds for the full mission 3B entry through landing trajectory. FDI results are presented in a "raw data" tabular format in order to furnish the reader with as much data tracking test detection and isolation performance data as is possible, with a minimal amount of data processing. Minimum 100% detection/isolation failure levels and a discussion of the effects of failure direction are presented. Finally, a limited comparison of failures introduced at trajectory initiation shows that the SPRT algorithm performs slightly worse than the data tracking test (Reference 1).

## 2.0 INTRODUCTION

Last September the SPRT algorithm was baselined at the Level B OFT Entry SDR to perform the onboard 2 and 3 IMU FDI testing with skewed IMU's. In order to both develop and verify the method, a subroutine incorporating the 2-IMU SPRT was added to the IMUFDI triple string IMU simulation program on the JSC Univac 1110. This report contains an evaluation of the present SPRT formulation (Reference 2) in detecting and identifying soft IMU failures.

## 3.0 DISCUSSION

The 2-IMU SPRT performance data presented in section 4.0 were generated by the IMUFDI program, version 18.C, interfaced with the 2-IMU SPRT subroutine, as described in Reference 2. The following paragraphs contain error modelling data, guidelines, and other

constants specifying the exact conditions under which the enclosed failure test case results were generated.

### 3.1 Guidelines

- Reference Mission 3B entry
- Simulation begins at entry interface (400 Kft.),  
and ends at touchdown, 1945 sec. after entry interface
- Only IMU #1 and IMU #2 are ON; IMU #3 is downmoded throughout all test cases
- All failures are introduced into IMU #1 at time  $t=0$  (400 Kft.)
- First detection/isolation tests are performed at time  $t=10$  sec., subsequent tests are performed every 5 sec. thereafter
- Each failure case is tested through 30 Monte Carlo cycles
- The 11° nav base pitch is modeled
- The Kearfott IMU gimbal sequence is used (ZYX-inner middle outer)

The following limitations of the IMUFDI program should be mentioned:

- All IMU's are assumed collocated.
- No tangential or centripetal forces are modeled.
- A 3 gimballed IMU error model is used, error in the 4th (inner roll) gimbal is unmodeled.
- This is an open loop simulation

### 3.2 Filter Constants

The first order whitening filter is characterized by the following constants:

**Autocorrelation time**

$$\tau_{\text{GYRO}} = 120 \text{ sec.}$$

$$\tau_{\text{ACCL}} = 120 \text{ sec.}$$

**Gains**

$$K_{\text{GYRO}} = .54$$

$$K_{\text{ACCL}} = .084$$

**3.3 Base Failure Thresholds**

The base failure thresholds are plotted in Figures 1 and 2, together with the 100 Monte Carlo cycle envelopes of nominal data before filtering. The gyro threshold is a 3rd order polynomial function of time, specified by the following coefficients:

$$\text{TGYRO}_0 = 3.7 \quad \text{E-4}$$

$$\text{TGYRO}_1 = 3.4967 \quad \text{E-6}$$

$$\text{TGYRO}_2 = -1.1786 \quad \text{E-10}$$

$$\text{TGYRO}_3 = -5.8263 \quad \text{E-13}$$

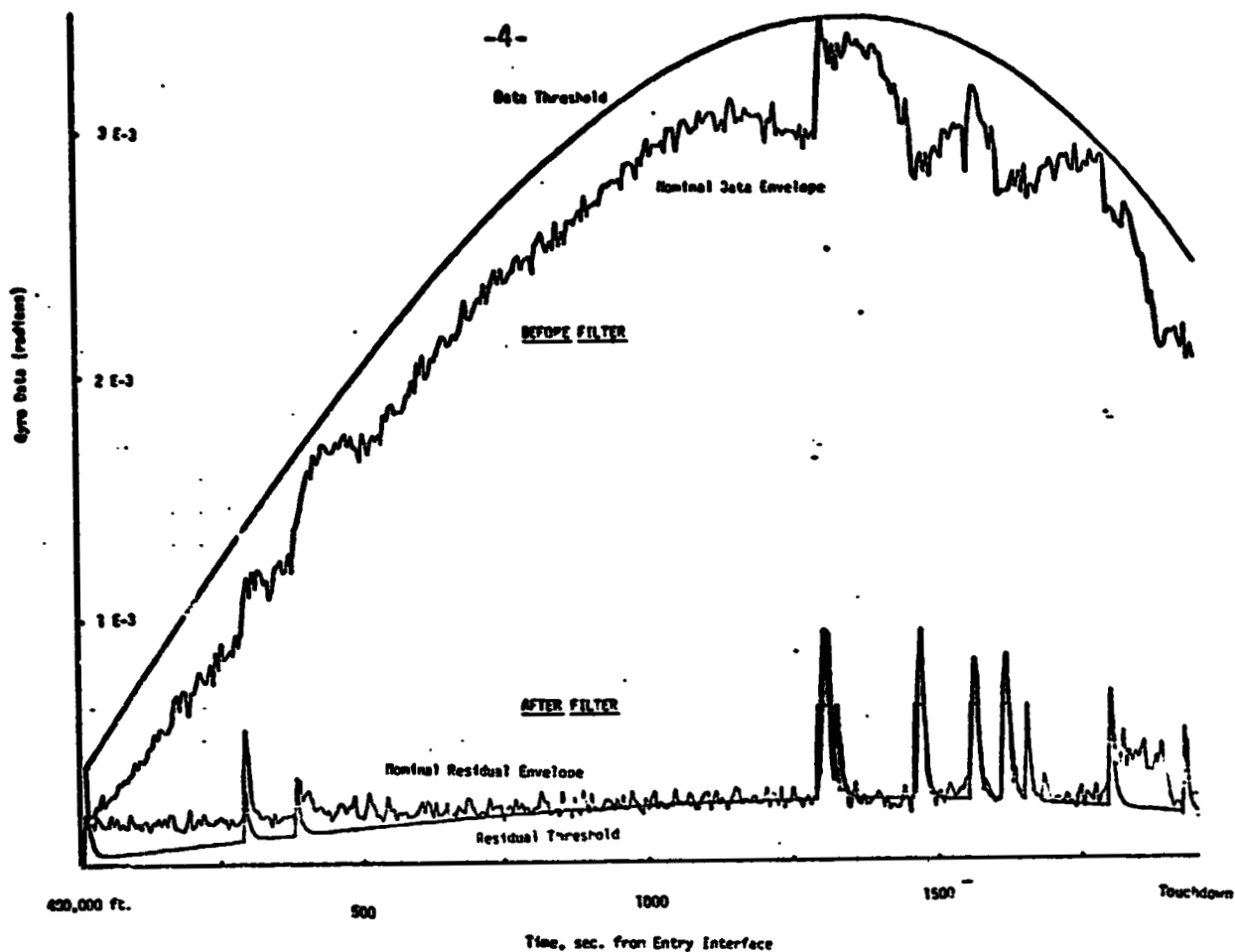


Figure 1. Total Relative Misalignments

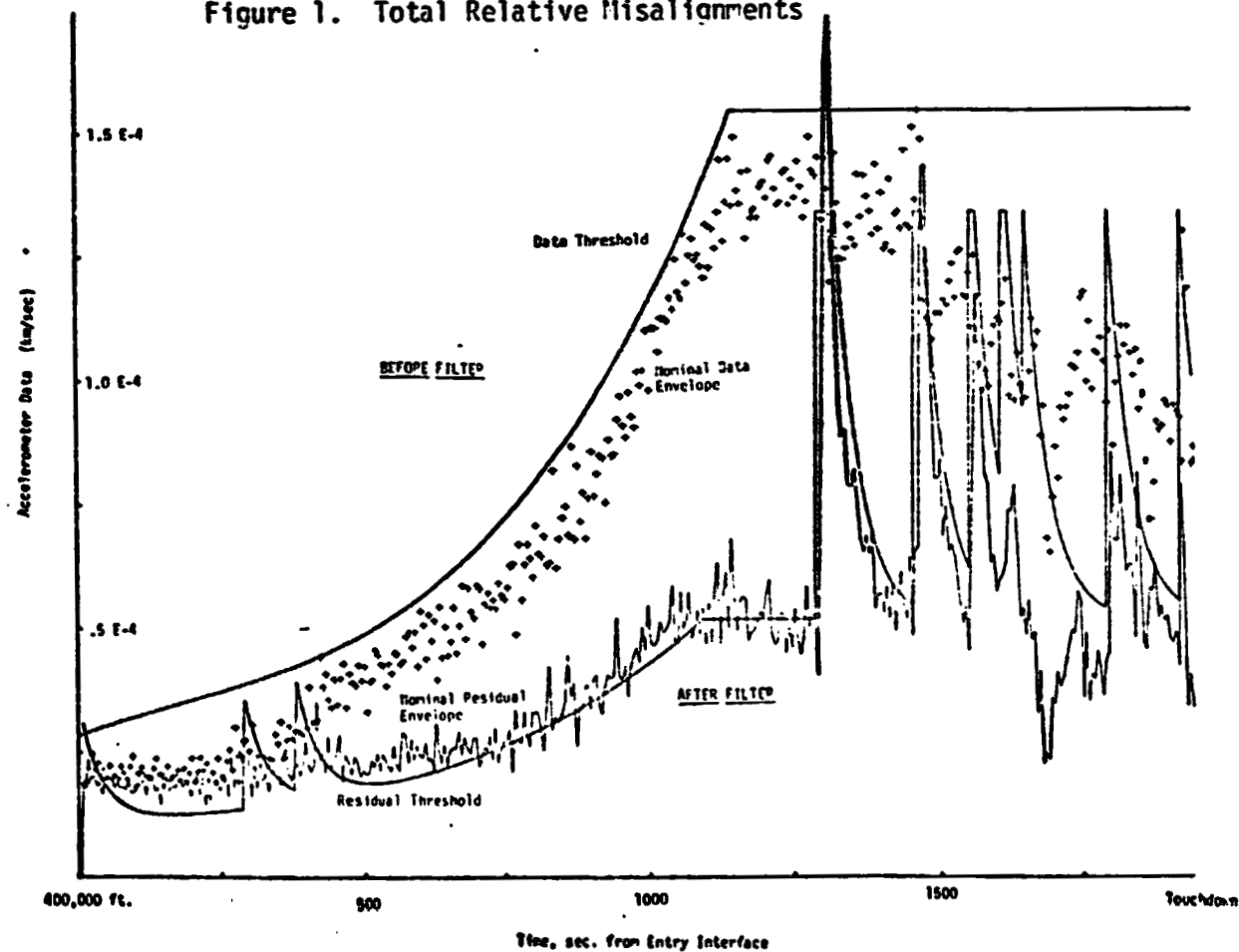


Figure 2. Incremental  $\Delta V$  Differences

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The accelerometer threshold is a 3rd order polynomial which latches to a constant level at  $t=1145$  sec. Before 1145, the threshold is specified by the following coefficients:

$$TACCL_0 = 2.83 \quad E-5$$

$$TACCL_1 = 4.3503 \quad E-8$$

$$TACCL_2 = -5.3665 \quad E-11$$

$$TACCL_3 = 9.7743 \quad E-14$$

### 3.4 Log Likelihood Ratio Constants

The failure thresholds on the residuals after filtering are also plotted in Figures 1 and 2, together with envelopes of 100 Monte Carlo cycle nominal residuals. These thresholds are calculated from the base failure thresholds as described in Reference 1 using the following constants:

Attitude Transient Percentage

$$P_{NB, GYRO} = .15$$

$$P_{NB, ACCL} = .80$$

Attitude Transient Detect Level

$$\Delta_{GIM} = .226 \text{ radians}$$

Residual Standard Deviation

$$\sigma_{GYRO} = 2.4E-4 \text{ rad}$$

$$\sigma_{ACCL} = 1.2E-5 \text{ Km/sec}$$

Mean False Alarm Rate

$$ALPHA = \Delta t/T = 5/5000 = 10^{-3}$$

Where  $T = 5000$  sec., mean time between false alarms

### 3.5 Skew Matrix

The ideal skewed transformation from IMU #1 to IMU #2 stable platform coordinate frames is given by:

$$T_{12} = \begin{bmatrix} -.5000000000 & .8090169944 & -.3090169944 \\ -.8090169944 & -.3090169944 & .5000000000 \\ .3090169944 & .5000000000 & .8090169944 \end{bmatrix}$$

### 3.6 IMU Platform to Nav Base Euler Matrix

The Kearfott IMU stable platform to navigation base transformation matrix is given by:

$$\begin{bmatrix} C\psi C\theta & C\psi S\theta & -S\psi \\ -C\phi S\theta + S\phi S\psi C\theta & C\phi C\theta + S\phi S\psi S\theta & S\phi C\psi \\ S\phi S\theta + C\phi S\psi C\theta & -S\phi C\theta + C\phi S\psi S\theta & C\phi C\psi \end{bmatrix}$$

where S=sine, C=cosine,  $\phi$ ,  $\psi$ ,  $\theta$  are the X, Y, Z gimbal angles, respectively.

### 3.7 IMU Entry Error Model

	Engineering Values	Program Values
<b>ACCELEROMETER ERRORS (1σ) per axis</b>		
bias	50 ug	.490333369-006 $\frac{\text{Km}}{\text{sec}^2}$
scale factor	100 PPM	.0001
input axis misalignment	15 arc sec	.727220522-004 rad.
quantization	$1 \times 10^{-5}$ km/sec	$1 \times 10^{-5}$ Km/sec
<b>GYRO ERRORS (1σ) per axis</b>		
bias drift	0.035 deg/hr	.169684788-006 $\frac{\text{rad}}{\text{sec}}$
g-sensitive drift-input axis	0.025 deg/hr/g	.123592917-004 $\frac{(\text{rad/sec})}{(\text{Km/sec}^2)}$
g-sensitive drift-spin axis	0.025 deg/hr/g	.123592917-004 $\frac{(\text{rad/sec})}{(\text{Km/sec}^2)}$
g <sup>2</sup> -sensitive drift-input/spin axis	0.025 deg/hr/g <sup>2</sup>	.125826815-002 $\frac{(\text{rad/sec})}{(\text{Km/sec}^2)^2}$
scale factor	200 PPM	.0002
mounting alignment	60 arc sec	.290888209-003 rad
<b>IMU ERRORS (1σ)</b>		
IMU to nav. base	42.4 arc sec	.2056890249-003 rad
gimbal non-orthogonality	50 arc sec	.2424068405-003 rad
resolver bias term	0.	0
resolver sinusoidal term	30 arc sec	.1454441043-003 rad
resolver multiplicative speed	2	2
gimbal quantization	20 arc sec	.9696273622-004 rad
<b>INITIAL ALIGNMENT ERRORS (1σ)</b>		
each axis	132 arc sec	.6399540589-003 rad



#### 4.0 RESULTS

Detection and isolation sensitivities of the 2-IMU SPRT algorithm were tested on failures in gyro drift, accelerometer bias, and accelerometer scale factor, introduced into IMU #1 at  $t=0$  (400,000 ft). Failure levels were selected to correspond with the cases tested in Reference 2 so that performance of the SPRT and data tracking test could be compared under similar conditions. Failures in the following orientations were examined:

Single axis: X, Y, and Z axes

Dual axis:  $-45^\circ$  and  $+45^\circ$  in XY plane

Finally, for the sake of completeness, SPRT performance in the presence of no failure is summarized.

Each failure case is summarized in a six column table. The first column is the Monte Carlo cycle number. The second is the time (sec. from entry interface) of the first detection; this number will be equal to zero if there has been no detection during the cycle. The third column is the type of detection, ACCL or GYRO; this field will be blank if there has been no detection. Columns 4 and 5 are the same as columns 2 and 3, except that they pertain to the first isolation instead of the first detection. The sixth column is the IMU configuration control flag AFAIL, which is set after the first isolation. This number should be equal to 5 for all IMU #1 failures; it would be equal to 6 if the isolation logic indicated an IMU #2 failure.

##### 4.1 Gyro Drift

Tables 1, 2, and 3 contain FDI performance summaries for  $.5^\circ/\text{hr}$ ,  $1^\circ/\text{hr}$ , and  $2^\circ/\text{hr}$  failures, respectively. The following observations are made on the basis of these data:

- .5°/hr detection was high but never 100%, ranging from 83% in the Z axis case to 97% in the -45° case
- 1°/hr isolation was 100% in only the +45° case, falling to 97% in the Y and Z cases, to 43% in the X case and 3% in the -45° case
- 2°/hr isolation was 100% in all but the -45° case. Average isolation times were sharply reduced from the 1°/hr cases. For example, Y axis average isolation time fell from 1515 sec. to 479 sec.

#### 4.2 Accelerometer Bias

Tables 4, 5, and 6 contain FDI performance summaries for 1000 $\mu$ g, 1200 $\mu$ g, and 2000 $\mu$ g failures, respectively. The following observations are made on the basis of these data:

- 1000 $\mu$ g detection was high but never 100%, ranging from 87% in the -45° and Y cases to 93% in the X axis case
- 1200 $\mu$ g detection was 100% in all cases. 1200 $\mu$ g isolation ranged from 0% in the -45° and X cases to 50% in the +45° case
- 2000 $\mu$ g isolation was 100% in the +45°, Y, and Z cases, falling to 20% in the X case and 3% in the -45° case.

#### 4.3 Accelerometer Scale Factor Error

Tables 7, 8, and 9 contain FDI performance summaries for 3000ppm, 5000ppm, and 8000ppm failures, respectively. The following observations are made on the basis of these data:

- The 100% detection level lies between 3000ppm and 5000ppm
- 5000ppm isolation was at best 90% in the X axis case

- 8000ppm isolation was 100% in the -45°, Y, and Z cases, falling to 97% in the +45° case, and to 63% in the X axis case.

#### 4.4 Nominal

Table 10 contains the FDI performance summary in the nominal case. In a separate run (not included) the algorithm was tested during 100 nominal Monte Carlo cycles with no false detection or isolation.

### 5.0 CONCLUSIONS

The following conclusions are made on the basis of the data contained in section 4.0.

- For all cases run with the SPRT, there were no false detections in a 100 Monte Carlo cycle nominal case, and no incorrect isolations in the failure cases.
- Failure detection was sensitive, for all failure orientations, with the following 100% detection levels
  - gyro drift  $\approx .6^\circ/\text{hr}$
  - accelerometer bias  $\approx 1100\mu\text{g}$
  - accelerometer scale factor  $\approx 4000\text{ppm}$
- For the IMU pair tested (#1, #2), the best isolation geometry holds for the +45°, Y, and Z axis cases. Best geometry 100% isolation levels were found to be:
  - gyro drift  $1^\circ/\text{hr}$
  - accelerometer bias  $1400\mu\text{g}$
  - accelerometer scale factor  $6000\text{ppm}$
- -45° and X axis failures in gyro drift and accelerometer bias exhibited poor isolation geometry, since they were closest to the ambiguity line at -31.7° in the XY plane discussed in the

appendix of Reference 3. In the  $-45^\circ$  case,  $1^\circ/\text{hr}$  isolation fell to 3%, and  $2000\mu\text{g}$  isolation fell to 3%.

Reference 1 presented the following 100% levels for the tracking test:

Detection:  $.5^\circ/\text{hr}$ ,  $800\mu\text{g}$ ,  $4000\text{ppm}$

Isolation:  $1^\circ/\text{hr}$ ,  $1200\mu\text{g}$ ,  $5000\text{ppm}$

Comparing these levels with those above for SPRT, the tracking test is slightly more sensitive than the SPRT. A comparison of response times shows the tracking test to be slightly faster in detection/isolation than the SPRT.

## 6.0 REFERENCES

1. T. M. Rich, "Performance Results of the Data Tracking Test for 2-IMU FDI," MDTSCO Working Paper No. E914-8A-026, 27 Feb. 1976.
2. T. M. Rich, "A Detailed Description of the Sequential Probability Ratio Test for 2-IMU FDI", MDTSCO Design Note No. D0410-007, 24 March 1976.
3. T. M. Rich, "Performance of the version 17.B Two IMU Single Axis FDI Logic in Detecting and Isolating Dual Axis Gyro Failures", MDTSCO Working Paper No. E914-8A-003, 18 Oct. 1974.

SPRY DETECTION/ISOLATION PERFORMANCE SUMMARY -12-

CYCLE	1ST DETECTION	1ST ISOLATION
1	1835 GYRO	0
2	1835 GYRO	0
3	1830 GYRO	0
4	1830 GYRO	0
5	1835 GYRO	0
6	1835 GYRO	0
7	1775 GYRO	0
8	1870 GYRO	0
9	1780 GYRO	0
10	1755 GYRO	0
11	1835 GYRO	0
12	1765 GYRO	0
13	1825 GYRO	0
14	1780 GYRO	0
15	1735 GYRO	0
16	1780 GYRO	0
17	1785 GYRO	0
18	1745 GYRO	0
19	1855 GYRO	0
20	1845 GYRO	0
21	1880 GYRO	0
22	1720 GYRO	0
23	1860 GYRO	0
24	1895 GYRO	0
25	1840 GYRO	0
26	1720 GYRO	0
27	1530 GYRO	0
28	1840 GYRO	0
29	1745 GYRO	0
30	1430 GYRO	0
48990		0

a) -45° in XY plane

SPRY DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE	1ST DETECTION	1ST ISOLATION
1	1855 GYRO	0
2	0	0
3	1830 GYRO	0
4	1815 GYRO	0
5	1845 GYRO	0
6	1745 GYRO	0
7	1870 GYRO	0
8	0	0
9	0	0
10	1845 GYRO	0
11	1385 GYRO	0
12	1855 GYRO	0
13	1810 GYRO	0
14	1840 GYRO	0
15	1840 GYRO	1875 GYRO
16	0	0
17	940 GYRO	0
18	1540 GYRO	0
19	1870 GYRO	0
20	1715 GYRO	0
21	1750 GYRO	0
22	1845 GYRO	0
23	1250 GYRO	0
24	945 GYRO	0
25	1555 GYRO	0
26	1640 GYRO	0
27	465 GYRO	0
28	1820 GYRO	0
29	610 GYRO	0
30	1825 GYRO	0
41575		1875

b) X axis

SPRY DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE	1ST DETECTION	1ST ISOLATION
1	1855 GYRO	0
2	0	0
3	1855 GYRO	1900 GYRO
4	1845 GYRO	1875 GYRO
5	1865 GYRO	0
6	1840 GYRO	0
7	1740 GYRO	1870 GYRO
8	1775 GYRO	0
9	0	0
10	1840 GYRO	1905 GYRO
11	1445 GYRO	0
12	1905 GYRO	0
13	0	0
14	1845 GYRO	0
15	1845 GYRO	1860 GYRO
16	0	0
17	1770 GYRO	0
18	1765 GYRO	0
19	0	0
20	1730 GYRO	0
21	1860 GYRO	0
22	1895 GYRO	0
23	1885 GYRO	0
24	1055 GYRO	1550 GYRO
25	1865 GYRO	0
26	1855 GYRO	0
27	475 GYRO	0
28	1840 GYRO	1890 GYRO
29	1740 GYRO	0
30	1835 GYRO	1885 GYRO
43245		14735

c) +45° in XY plane

SPRY DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE	1ST DETECTION	1ST ISOLATION
1	1760 GYRO	0
2	1715 GYRO	0
3	1550 GYRO	0
4	1870 GYRO	0
5	1910 GYRO	0
6	1840 GYRO	0
7	410 GYRO	1745 GYRO
8	1750 GYRO	0
9	1775 GYRO	0
10	1860 GYRO	0
11	1785 GYRO	0
12	1735 GYRO	0
13	0	0
14	1845 GYRO	0
15	1865 GYRO	0
16	1735 GYRO	0
17	1830 GYRO	0
18	1440 GYRO	0
19	1710 GYRO	0
20	1720 GYRO	0
21	1725 GYRO	0
22	1860 GYRO	0
23	780 GYRO	0
24	0	0
25	730 GYRO	0
26	1855 GYRO	0
27	410 GYRO	0
28	1780 GYRO	0
29	795 GYRO	0
30	1775 GYRO	0
46845		1785

d) Y axis

SPRY DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE	1ST DETECTION	1ST ISOLATION
1	1745 GYRO	0
2	1775 GYRO	0
3	1715 GYRO	1715 GYRO
4	1455 GYRO	1850 GYRO
5	1780 GYRO	0
6	1890 GYRO	0
7	1395 GYRO	0
8	1440 GYRO	0
9	1865 GYRO	1910 GYRO
10	900 GYRO	0
11	0	0
12	1775 GYRO	1875 GYRO
13	1455 GYRO	0
14	1845 GYRO	0
15	1735 GYRO	1860 GYRO
16	1575 GYRO	1795 GYRO
17	1905 GYRO	0
18	0	0
19	1265 GYRO	1870 GYRO
20	1770 GYRO	1910 GYRO
21	1890 GYRO	0
22	0	0
23	0	0
24	1215 GYRO	1855 GYRO
25	1875 GYRO	1915 GYRO
26	1550 GYRO	1875 GYRO
27	1870 GYRO	0
28	1790 GYRO	0
29	0	0
30	1860 GYRO	0
41335		20430

e) Z axis

Table 1. .5 °/hr Gyro Drift, IMU #1

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### SPOT DETECTION/ISOLATION PERFORMANCE SUMMARY

-13-

## SPR DETECTION/ISOLATION PERFORMANCE SUMMARY

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a)  $-45^\circ$  in XY plane

CYCLE	1ST DETECTION	1ST ISOLATION
1	467	1940
2	1140	1940
3	1155	1890
4	1415	1865
5	560	
6	525	
7	475	1735
8	435	1720
9	585	
10	495	1875
11	475	
12	435	1900
13	495	
14	675	
15	765	1845
16	645	1815
17	485	
18	425	
19	755	
20	570	
21	535	
22	285	
23	620	
24	685	1290
25	655	
26	1655	1920
27	245	
28	1135	1885
29	510	
30	1135	1575
	<u>29295</u>	<u>23555</u>

**b) X axis**

### SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE	1ST DETECTION	1ST ISOLATION
1	1215	GYRO
2	1175	GYRO
3	1095	GYRO
4	1075	GYRO
5	1085	GYRO
6	1055	GYRO
7	375	GYRO
8	635	GYRO
9	545	GYRO
10	1050	GYRO
11	575	GYRO
12	445	GYRO
13	1245	GYRO
14	645	GYRO
15	625	GYRO
16	625	GYRO
17	645	GYRO
18	515	GYRO
19	895	GYRO
20	655	GYRO
21	655	GYRO
22	655	GYRO
23	655	GYRO
24	655	GYRO
25	655	GYRO
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460	655	GYRO
461	655	GYRO
4		

c)  $+45^\circ$  in XY plane

### SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE	1ST DETECTION	1ST ISOLATION
1	1255	1710
2	1155	1555
3	1155	1555
4	1155	1555
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413	1155	1555
414	1155	1555
415	1155	1555
416		

**d) Y axis**

## SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE	1ST DETECTION	1ST ISOLATION
1	695	1120
2	325	735
3	535	585
4	935	1275
5	535	775
6	895	1275
7	355	1255
8	935	1255
9	1610	1735
10	455	1710
11	935	1710
12	285	1725
13	875	1755
14	1060	1735
15	345	1655
16	935	1625
17	2155	1155
18	345	1785
19	1655	1755
20	1390	1755
21	770	1735
22	595	1645
23	315	1725
24	515	1725
25	655	1735
26	335	1735
27	725	1735
28	875	1735
29	485	1735
30	50155	16575

**e) Z axis**

ORIGINAL PAGE IS  
OF POOR QUALITY.

CYCLE	1ST DETECTION	1ST ISOLATION
190	GYRO	0
180	GYRO	0
210	GYRO	0
175	GYRO	0
160	GYRO	0
190	GYRO	0
70	GYRO	0
95	GYRO	0
250	GYRO	1730 GYRO
135	GYRO	0
40	GYRO	1775 GYRO
300	GYRO	0
80	GYRO	1915 GYRO
15	GYRO	0
400	GYRO	0
260	GYRO	0
45	GYRO	1785 GYRO
200	GYRO	1865 GYRO
260	GYRO	0
250	GYRO	0
235	GYRO	1795 GYRO
190	GYRO	1915 GYRO
50	GYRO	1875 GYRO
265	GYRO	0
275	GYRO	1895 GYRO
170	GYRO	0
185	GYRO	1915 GYRO
235	GYRO	0
215	GYRO	1925 GYRO
198	GYRO	1760 GYRO
4500		22080

a)  $-45^\circ$  in XY plane

CYCLE	1ST DETECTION	1ST ISOLATION
1	270	8VRO
2	270	8VRO
3	270	8VRO
4	270	8VRO
5	270	8VRO
6	270	8VRO
7	270	8VRO
8	270	8VRO
9	270	8VRO
10	270	8VRO
11	270	8VRO
12	270	8VRO
13	270	8VRO
14	270	8VRO
15	270	8VRO
16	270	8VRO
17	270	8VRO
18	270	8VRO
19	270	8VRO
20	270	8VRO
21	270	8VRO
22	270	8VRO
23	270	8VRO
24	270	8VRO
25	270	8VRO
26	270	8VRO
27	270	8VRO
28	270	8VRO
29	270	8VRO
30	270	8VRO
	6300	35020

**b) X axis**

SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY			
CYCLE	1ST DETECTION	1ST ISOLATION	
1	2170	6790	31
2	2170	6790	32
3	2170	6790	33
4	2170	6790	34
5	2170	6790	35
6	2170	6790	36
7	2170	6790	37
8	2170	6790	38
9	2170	6790	39
10	2170	6790	40
11	2170	6790	41
12	2170	6790	42
13	2170	6790	43
14	2170	6790	44
15	2170	6790	45
16	2170	6790	46
17	2170	6790	47
18	2170	6790	48
19	2170	6790	49
20	2170	6790	50
21	2170	6790	51
22	2170	6790	52
23	2170	6790	53
24	2170	6790	54
25	2170	6790	55
26	2170	6790	56
27	2170	6790	57
28	2170	6790	58
29	2170	6790	59
30	2170	6790	60
31	2170	6790	61
32	2170	6790	62
33	2170	6790	63
34	2170	6790	64
35	2170	6790	65
36	2170	6790	66
37	2170	6790	67
38	2170	6790	68
39	2170	6790	69
40	2170	6790	70
41	2170	6790	71
42	2170	6790	72
43	2170	6790	73
44	2170	6790	74
45	2170	6790	75
46	2170	6790	76
47	2170	6790	77
48	2170	6790	78
49	2170	6790	79
50	2170	6790	80
51	2170	6790	81
52	2170	6790	82
53	2170	6790	83
54	2170	6790	84
55	2170	6790	85
56	2170	6790	86
57	2170	6790	87
58	2170	6790	88
59	2170	6790	89
60	2170	6790	90
61	2170	6790	91
62	2170	6790	92
63	2170	6790	93
64	2170	6790	94
65	2170	6790	95
66	2170	6790	96
67	2170	6790	97
68	2170	6790	98
69	2170	6790	99
70	2170	6790	100
71	2170	6790	101
72	2170	6790	102
73	2170	6790	103
74	2170	6790	104
75	2170	6790	105
76	2170	6790	106
77	2170	6790	107
78	2170	6790	108
79	2170	6790	109
80	2170	6790	110
81	2170	6790	111
82	2170	6790	112
83	2170	6790	113
84	2170	6790	114
85	2170	6790	115
86	2170	6790	116
87	2170	6790	117
88	2170	6790	118
89	2170	6790	119
90	2170	6790	120
91	2170	6790	121
92	2170	6790	122
93	2170	6790	123
94	2170	6790	124
95	2170	6790	125
96	2170	6790	126
97	2170	6790	127
98	2170	6790	128
99	2170	6790	129
100	2170	6790	130
101	2170	6790	131
102	2170	6790	132
103	2170	6790	133
104	2170	6790	134
105	2170	6790	135
106	2170	6790	136
107	2170	6790	137
108	2170	6790	138
109	2170	6790	139
110	2170	6790	140
111	2170	6790	141
112	2170	6790	142
113	2170	6790	143
114	2170	6790	144
115	2170	6790	145
116	2170	6790	146
117	2170	6790	147
118	2170	6790	148
119	2170	6790	149
120	2170	6790	150
121	2170	6790	151
122	2170	6790	152
123	2170	6790	153
124	2170	6790	154
125	2170	6790	155
126	2170	6790	156
127	2170	6790	157
128	2170	6790	158
129	2170	6790	159
130	2170	6790	160
131	2170	6790	161
132	2170	6790	162
133	2170	6790	163
134	2170	6790	164
135	2170	6790	165
136	2170	6790	166
137	2170	6790	167
138	2170	6790	168
139	2170	6790	169
140	2170	6790	170
141	2170	6790	171
142	2170	6790	172
143	2170	6790	173
144	2170	6790	174
145	2170	6790	175
146	2170	6790	176
147	2170	6790	177
148	2170	6790	178
149	2170	6790	179
150	2170	6790	180
151	2170	6790	181
152	2170	6790	182
153	2170	6790	183
154	2170	6790	184
155	2170	6790	185
156	2170	6790	186
157	2170	6790	187
158	2170	6790	188
159	2170	6790	189
160	2170	6790	190
161	2170	6790	191
162	2170	6790	192
163	2170	6790	193
164	2170	6790	194
165	2170	6790	195
166	2170	6790	196
167	2170	6790	197
168	2170	6790	198
169	2170	6790	199
170	2170	6790	200
171	2170	6790	201
172	2170	6790	202
173	2170	6790	203
174	2170	6790	204
175	2170	6790	205
176	2170	6790	206
177	2170	6790	207
178	2170	6790	208
179	2170	6790	209
180	2170	6790	210
181	2170	6790	211
182	2170	6790	212
183	2170	6790	213
184	2170	6790	214
185	2170	6790	215
186	2170	6790	216
187	2170	6790	217
188	2170	6790	218
189	2170	6790	219
190	2170	6790	220
191	2170	6790	221
192	2170	6790	222
193	2170	6790	223
194	2170	6790	224
195	2170	6790	225
196	2170	6790	226
197	2170	6790	227
198	2170	6790	228
199	2170	6790	229
200	2170	6790	230
201	2170	6790	231
202	2170	6790	232
203	2170	6790	233
204	2170	6790	234
205	2170	6790	235
206	2170	6790	236
207	2170	6790	237
208	2170	6790	238
209	2170	6790	239
210	2170	6790	240
211	2170	6790	241
212	2170	6790	242
213	2170	6790	243
214	2170	6790	244
215	2170	6790	245
216	2170	6790	246
217	2170	6790	247
218	2170	6790	248
219	2170	6790	249
220	2170	6790	250
221	2170	6790	251
222	2170	6790	252
223	2170	6790	253
224	2170	6790	254
225	2170	6790	255
226	2170	6790	256
227	2170	6790	257
228	2170	6790	258
229	2170	6790	259
230	2170	6790	260
231	2170	6790	261
232	2170	6790	262
233	2170	6790	263
234	2170	6790	264
235	2170	6790	265
236	2170	6790	266
237	2170	6790	267
238	2170	6790	268
239	2170	6790	269
240	2170	6790	270
241	2170	6790	271
242	2170	6790	272
243	2170	6790	273
244	2170	6790	274
245	2170	6790	275
246	2170	6790	276
247	2170	6790	277
248	2170	6790	278
249	2170	6790	279
250	2170	6790	280
251	2170	6790	281
252	2170	6790	282
253	2170	6790	283
254	2170	6790	284
255	2170	6790	285
256	2170	6790	286
257	2170	6790	287
258	2170	6790	288
259	2170	6790	289
260	2170	6790	290
261	2170	6790	291
262	2170	6790	292
263	2170	6790	293
264	2170	6790	294
265	2170	6790	295
266	2170	6790	296
267	2170	6790	297
268	2170	6790	298
269	2170	6790	299
270	2170	6790	300
271	2170	6790	301
272	2170	6790	302
273	2170	6790	303
274	2170	6790	304
275	2170	6790	305
276	2170	6790	306
277	2170	6790	307
278	2170	6790	308
279	2170	6790	309
280	2170	6790	310
281	2170	6790	311
282	2170	6790	312
283	2170	6790	313
284	2170	6790	314
285	2170	6790	315
286	2170	6790	316
287	2170	6790	317
288	2170	6790	318
289	2170	6790	319
290	2170	6790	320
291	2170	6790	321
292	2170	6790	322
293	2170	6790	323
294	2170	6790	324
295	2170	6790	325
296	2170	6790	326
297	2170	6790	327
298	2170	6790	328
299	2170	6790	329
300	2170	6790	330
301	2170	6790	331
302	2170	6790	332
303	2170	6790	333
304	2170	6790	334
305	2170	6790	335
306	2170	6790	336
307	2170	6790	337
308	2170	6790	338
309	2170	6790	339
310	2170	6790	340
311	2170	6790	341
312	2170	6790	342
313	2170	6790	343
314	2170	6790	344
315	2170	6790	345
316	2170	6790	346
317	2170	6790	347
318	2170	6790	348
319	2170	6790	349
320	2170	6790	350
321	2170	6790	351
322	2170	6790	352
323	2170	6790	353
324	2170	6790	354
325	2170	6790	355
326	2170	6790	356
327	2170	6790	357
328	2170	6790	358
329	2170	6790	359

**c)  $+45^\circ$  in XY plane**

SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY					
CYCLE	1ST DETECTION		1ST ISOLATION		
1	265	GYRO	360	GYRO	S
2	310	GYRO	540	GYRO	S
3	315	GYRO	425	GYRO	S
4	310	GYRO	675	GYRO	S
5	310	GYRO	607	GYRO	S
6	310	GYRO	600	GYRO	S
7	310	GYRO	290	GYRO	S
8	310	GYRO	445	GYRO	S
9	315	GYRO	540	GYRO	S
10	315	GYRO	610	GYRO	S
11	310	GYRO	620	GYRO	S
12	315	GYRO	260	GYRO	S
13	315	GYRO	565	GYRO	S
14	315	GYRO	630	GYRO	S
15	315	GYRO	260	GYRO	S
16	315	GYRO	355	GYRO	S
17	315	GYRO	705	GYRO	S
18	315	GYRO	365	GYRO	S
19	315	GYRO	310	GYRO	S
20	315	GYRO	480	GYRO	S
21	315	GYRO	605	GYRO	S
22	315	GYRO	310	GYRO	S
23	315	GYRO	430	GYRO	S
24	315	GYRO	260	GYRO	S
25	315	GYRO	255	GYRO	S
26	315	GYRO	580	GYRO	S
27	315	GYRO	320	GYRO	S
28	315	GYRO	765	GYRO	S
29	315	GYRO	320	GYRO	S
30	315	GYRO	780	GYRO	S
	6465		14388		

**d) Y axis**

[illegible]

**e) Z axis**

**Table 3. 2 °/hr Gyro Drift, IMU #1**

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OF POOR QUALITY

SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

-15-

SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE	1ST DETECTION	1ST ISOLATION
1	ACCL	
2	ACCL	
3	ACCL	
4	ACCL	
5	ACCL	
6	ACCL	
7	ACCL	
8	ACCL	
9	ACCL	
10	ACCL	
11	ACCL	
12	ACCL	
13	ACCL	
14	ACCL	
15	ACCL	
16	ACCL	
17	ACCL	
18	ACCL	
19	ACCL	
20	ACCL	
21	ACCL	
22	ACCL	
23	ACCL	
24	ACCL	
25	ACCL	
26	ACCL	
27	ACCL	
28	ACCL	
29	ACCL	
30	ACCL	
31	ACCL	
32	ACCL	
33	ACCL	
34	ACCL	
35	ACCL	
36	ACCL	
37	ACCL	
38	ACCL	
39	ACCL	
40	ACCL	
41	ACCL	
42	ACCL	
43	ACCL	
44	ACCL	
45	ACCL	
46	ACCL	
47	ACCL	
48	ACCL	
49	ACCL	
50	ACCL	

a) -45° in XY plane

CYCLE	1ST DETECTION	1ST ISOLATION
1	ACCL	
2	ACCL	
3	ACCL	
4	ACCL	
5	ACCL	
6	ACCL	
7	ACCL	
8	ACCL	
9	ACCL	
10	ACCL	
11	ACCL	
12	ACCL	
13	ACCL	
14	ACCL	
15	ACCL	
16	ACCL	
17	ACCL	
18	ACCL	
19	ACCL	
20	ACCL	
21	ACCL	
22	ACCL	
23	ACCL	
24	ACCL	
25	ACCL	
26	ACCL	
27	ACCL	
28	ACCL	
29	ACCL	
30	ACCL	
31	ACCL	
32	ACCL	
33	ACCL	
34	ACCL	
35	ACCL	
36	ACCL	
37	ACCL	
38	ACCL	
39	ACCL	
40	ACCL	
41	ACCL	
42	ACCL	
43	ACCL	
44	ACCL	
45	ACCL	
46	ACCL	
47	ACCL	
48	ACCL	
49	ACCL	
50	ACCL	

b) X axis

SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE	1ST DETECTION	1ST ISOLATION
1	ACCL	
2	ACCL	
3	ACCL	
4	ACCL	
5	ACCL	
6	ACCL	
7	ACCL	
8	ACCL	
9	ACCL	
10	ACCL	
11	ACCL	
12	ACCL	
13	ACCL	
14	ACCL	
15	ACCL	
16	ACCL	
17	ACCL	
18	ACCL	
19	ACCL	
20	ACCL	
21	ACCL	
22	ACCL	
23	ACCL	
24	ACCL	
25	ACCL	
26	ACCL	
27	ACCL	
28	ACCL	
29	ACCL	
30	ACCL	
31	ACCL	
32	ACCL	
33	ACCL	
34	ACCL	
35	ACCL	
36	ACCL	
37	ACCL	
38	ACCL	
39	ACCL	
40	ACCL	
41	ACCL	
42	ACCL	
43	ACCL	
44	ACCL	
45	ACCL	
46	ACCL	
47	ACCL	
48	ACCL	
49	ACCL	
50	ACCL	

c) +45° in XY plane

CYCLE	1ST DETECTION	1ST ISOLATION
1	ACCL	
2	ACCL	
3	ACCL	
4	ACCL	
5	ACCL	
6	ACCL	
7	ACCL	
8	ACCL	
9	ACCL	
10	ACCL	
11	ACCL	
12	ACCL	
13	ACCL	
14	ACCL	
15	ACCL	
16	ACCL	
17	ACCL	
18	ACCL	
19	ACCL	
20	ACCL	
21	ACCL	
22	ACCL	
23	ACCL	
24	ACCL	
25	ACCL	
26	ACCL	
27	ACCL	
28	ACCL	
29	ACCL	
30	ACCL	
31	ACCL	
32	ACCL	
33	ACCL	
34	ACCL	
35	ACCL	
36	ACCL	
37	ACCL	
38	ACCL	
39	ACCL	
40	ACCL	
41	ACCL	
42	ACCL	
43	ACCL	
44	ACCL	
45	ACCL	
46	ACCL	
47	ACCL	
48	ACCL	
49	ACCL	
50	ACCL	

d) Y axis

SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE	1ST DETECTION	1ST ISOLATION
1	ACCL	
2	ACCL	
3	ACCL	
4	ACCL	
5	ACCL	
6	ACCL	
7	ACCL	
8	ACCL	
9	ACCL	
10	ACCL	
11	ACCL	
12	ACCL	
13	ACCL	
14	ACCL	
15	ACCL	
16	ACCL	
17	ACCL	
18	ACCL	
19	ACCL	
20	ACCL	
21	ACCL	
22	ACCL	
23	ACCL	
24	ACCL	
25	ACCL	
26	ACCL	
27	ACCL	
28	ACCL	
29	ACCL	
30	ACCL	
31	ACCL	
32	ACCL	
33	ACCL	
34	ACCL	
35	ACCL	
36	ACCL	
37	ACCL	
38	ACCL	
39	ACCL	
40	ACCL	
41	ACCL	
42	ACCL	
43	ACCL	
44	ACCL	
45	ACCL	
46	ACCL	
47	ACCL	
48	ACCL	
49	ACCL	
50	ACCL	

Table 4. 1000 µg Accelerometer Bias, IMU #1

ORIGINAL PAGE IS  
OF POOR QUALITY



1ST	2ND	3RD	4TH	5TH	6TH	7TH	8TH	9TH	10TH	11TH	12TH	13TH	14TH	15TH	16TH	17TH	18TH	19TH	20TH	21TH	22TH	23TH	24TH	25TH	26TH	27TH	28TH	29TH	30TH	31ST
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31

**b) X axis**

SPOT DETECTION/ISOLATION PERFORMANCE SUMMARY			
CYCLE	1ST DETECTION	1ST ISOLATION	
1	100%	100%	
2	100%	100%	
3	100%	100%	
4	100%	100%	
5	100%	100%	
6	100%	100%	
7	100%	100%	
8	100%	100%	
9	100%	100%	
10	100%	100%	
11	100%	100%	
12	100%	100%	
13	100%	100%	
14	100%	100%	
15	100%	100%	
16	100%	100%	
17	100%	100%	
18	100%	100%	
19	100%	100%	
20	100%	100%	
21	100%	100%	
22	100%	100%	
23	100%	100%	
24	100%	100%	
25	100%	100%	
26	100%	100%	
27	100%	100%	
28	100%	100%	
29	100%	100%	
30	100%	100%	
31	100%	100%	
32	100%	100%	
33	100%	100%	
34	100%	100%	
35	100%	100%	
36	100%	100%	
37	100%	100%	
38	100%	100%	
39	100%	100%	
40	100%	100%	
41	100%	100%	
42	100%	100%	
43	100%	100%	
44	100%	100%	
45	100%	100%	
46	100%	100%	
47	100%	100%	
48	100%	100%	
49	100%	100%	
50	100%	100%	
51	100%	100%	
52	100%	100%	
53	100%	100%	
54	100%	100%	
55	100%	100%	
56	100%	100%	
57	100%	100%	
58	100%	100%	
59	100%	100%	
60	100%	100%	
61	100%	100%	
62	100%	100%	
63	100%	100%	
64	100%	100%	
65	100%	100%	
66	100%	100%	
67	100%	100%	
68	100%	100%	
69	100%	100%	
70	100%	100%	
71	100%	100%	
72	100%	100%	
73	100%	100%	
74	100%	100%	
75	100%	100%	
76	100%	100%	
77	100%	100%	
78	100%	100%	
79	100%	100%	
80	100%	100%	
81	100%	100%	
82	100%	100%	
83	100%	100%	
84	100%	100%	
85	100%	100%	
86	100%	100%	
87	100%	100%	
88	100%	100%	
89	100%	100%	
90	100%	100%	
91	100%	100%	
92	100%	100%	
93	100%	100%	
94	100%	100%	
95	100%	100%	
96	100%	100%	
97	100%	100%	
98	100%	100%	
99	100%	100%	
100	100%	100%	

**d) Y axis**

SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY			
CYCLE	1ST DETECTION	1ST ISOLATION	
1	ACCL	ACCL	
2	ACCL	ACCL	
3	ACCL	ACCL	
4	ACCL	ACCL	
5	ACCL	ACCL	
6	ACCL	ACCL	
7	ACCL	ACCL	
8	ACCL	ACCL	
9	ACCL	ACCL	
10	ACCL	ACCL	
11	ACCL	ACCL	
12	ACCL	ACCL	
13	ACCL	ACCL	
14	ACCL	ACCL	
15	ACCL	ACCL	
16	ACCL	ACCL	
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18	ACCL	ACCL	
19	ACCL	ACCL	
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31	ACCL	ACCL	
32	ACCL	ACCL	
33	ACCL	ACCL	
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36	ACCL	ACCL	
37	ACCL	ACCL	
38	ACCL	ACCL	
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41	ACCL	ACCL	
42	ACCL	ACCL	
43	ACCL	ACCL	
44	ACCL	ACCL	
45	ACCL	ACCL	
46	ACCL	ACCL	
47	ACCL	ACCL	
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49	ACCL	ACCL	
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51	ACCL	ACCL	
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58	ACCL	ACCL	
59	ACCL	ACCL	
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63	ACCL	ACCL	
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65	ACCL	ACCL	
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67	ACCL	ACCL	
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69	ACCL	ACCL	
70	ACCL	ACCL	
71	ACCL	ACCL	
72	ACCL	ACCL	
73	ACCL	ACCL	
74	ACCL	ACCL	
75	ACCL	ACCL	
76	ACCL	ACCL	
77	ACCL	ACCL	
78	ACCL	ACCL	
79	ACCL	ACCL	
80	ACCL	ACCL	
81	ACCL	ACCL	
82	ACCL	ACCL	
83	ACCL	ACCL	
84	ACCL	ACCL	
85	ACCL	ACCL	
86	ACCL	ACCL	
87	ACCL	ACCL	
88	ACCL	ACCL	
89	ACCL	ACCL	
90	ACCL	ACCL	
91	ACCL	ACCL	
92	ACCL	ACCL	
93	ACCL	ACCL	
94	ACCL	ACCL	
95	ACCL	ACCL	
96	ACCL	ACCL	
97	ACCL	ACCL	
98	ACCL	ACCL	
99	ACCL	ACCL	
100	ACCL	ACCL	

**Table 5. 1200  $\mu$ g Accelerometer Bias, IMU #1**

ORIGINAL PAGE IS  
OF POOR QUALITY

# SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

-17-

CYCLE	1ST DETECTION	1ST ISOLATION
1	ACCL	
2	ACCL	
3	ACCL	
4	ACCL	
5	ACCL	
6	ACCL	
7	ACCL	
8	ACCL	
9	ACCL	
10	ACCL	
11	ACCL	
12	ACCL	
13	ACCL	
14	ACCL	
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16	ACCL	
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18	ACCL	
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29	ACCL	
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32	ACCL	
33	ACCL	
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35	ACCL	
36	ACCL	
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42	ACCL	
43	ACCL	
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73	ACCL	
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81	ACCL	
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89	ACCL	
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121	ACCL	
122	ACCL	
123	ACCL	
124	ACCL	
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126	ACCL	
127	ACCL	
128	ACCL	
129	ACCL	
130	ACCL	
131	ACCL	
132	ACCL	
133	ACCL	
134	ACCL	
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139	ACCL	
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141	ACCL	
142	ACCL	
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144	ACCL	
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CYCLE	1ST DETECTION	1ST ISOLATION
1270	ACCL	0
821	ACCL	0
79	ACCL	1135 ACCL
94	ACCL	1715 ACCL
113	ACCL	0
1175	ACCL	0
1126	ACCL	0
1135	ACCL	0
1135	ACCL	0
975	ACCL	1745 ACCL
1135	ACCL	0
1115	ACCL	0
935	ACCL	1135 ACCL
1105	ACCL	0
1105	ACCL	0
1125	ACCL	0
1105	ACCL	0
94	ACCL	0
1105	ACCL	0
1145	ACCL	0
1115	ACCL	0
117	ACCL	0
1145	ACCL	0
975	ACCL	0
1135	ACCL	0
1105	ACCL	0
132	ACCL	0
66	ACCL	0
20160		4333

a)  $-45^\circ$  in XY plane

[illegible]

**b) X axis**

SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY			
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c)  $+45^\circ$  in XY plane

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4	663	ACCL	
5	885	ACCL	
6	465	ACCL	
7	765	ACCL	
8	797	ACCL	
9	885	ACCL	
10	987	ACCL	
11	537	ACCL	
12	857	ACCL	
13	535	ACCL	
14	955	ACCL	
15	227	ACCL	
16	937	ACCL	
17	575	ACCL	
18	787	ACCL	
19	887	ACCL	
20	917	ACCL	
21	835	ACCL	
22	835	ACCL	
23	945	ACCL	
24	775	ACCL	
25	775	ACCL	
26	767	ACCL	
27	837	ACCL	
28	745	ACCL	
29	495	ACCL	
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**d) Y axis**

SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY		
CYCLE	1ST DETECTION	1ST ISOLATION
1	1745	ACCL
2	1745	ACCL
3	1745	ACCL
4	1745	ACCL
5	1745	ACCL
6	1745	ACCL
7	1745	ACCL
8	1745	ACCL
9	1745	ACCL
10	1745	ACCL
11	1745	ACCL
12	1745	ACCL
13	1745	ACCL
14	1745	ACCL
15	1745	ACCL
16	1745	ACCL
17	1745	ACCL
18	1745	ACCL
19	1745	ACCL
20	1745	ACCL
21	1745	ACCL
22	1745	ACCL
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25	1745	ACCL
26	1745	ACCL
27	1745	ACCL
28	1745	ACCL
29	1745	ACCL
30	1745	ACCL
31	1745	ACCL
32	1745	ACCL
33	1745	ACCL
34	1745	ACCL
35	1745	ACCL
36	1745	ACCL
37	1745	ACCL
38	1745	ACCL
39	1745	ACCL
40	1745	ACCL
41	1745	ACCL
42	1745	ACCL
43	1745	ACCL
44	1745	ACCL
45	1745	ACCL
46	1745	ACCL
47	1745	ACCL
48	1745	ACCL
49	1745	ACCL
50	1745	ACCL
51	1745	ACCL
52	1745	ACCL
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64	1745	ACCL
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66	1745	ACCL
67	1745	ACCL
68	1745	ACCL
69	1745	ACCL
70	1745	ACCL
71	1745	ACCL
72	1745	ACCL
73	1745	ACCL
74	1745	ACCL
75	1745	ACCL
76	1745	ACCL
77	1745	ACCL
78	1745	ACCL
79	1745	ACCL
80	1745	ACCL
81	1745	ACCL
82	1745	ACCL
83	1745	ACCL
84	1745	ACCL
85	1745	ACCL
86	1745	ACCL
87	1745	ACCL
88	1745	ACCL
89	1745	ACCL
90	1745	ACCL
91	1745	ACCL
92	1745	ACCL
93	1745	ACCL
94	1745	ACCL
95	1745	ACCL
96	1745	ACCL
97	1745	ACCL
98	1745	ACCL
99	1745	ACCL
100	1745	ACCL

**e) Z axis**

**Table 7. 3000 ppm Scale Factor Error, IMU #1**

ORIGINAL PAGE IS  
OF POOR QUALITY

## SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

-19-

CYCLE	1ST DETECTION	1ST ISOLATION
307	ACCL	1
378	ACCL	1
39	ACCL	1
40	ACCL	1
40.5	ACCL	1445 ACCL
46	ACCL	110 ACCL
46.5	ACCL	79 ACCL
48.5	ACCL	915 ACCL
51	ACCL	035 ACCL
52.5	ACCL	1265 ACCL
6.5	ACCL	0.1 ACCL
49.5	ACCL	96.1 ACCL
5.5	ACCL	99.2 ACCL
50	ACCL	1.5 ACCL
46.5	ACCL	1.55 ACCL
49	ACCL	1.15 ACCL
47	ACCL	1.15 ACCL
53	ACCL	1.15 ACCL
48	ACCL	1.15 ACCL
45	ACCL	1.15 ACCL
51	ACCL	1.15 ACCL
51	ACCL	1.15 ACCL
50	ACCL	1.15 ACCL
47	ACCL	1.15 ACCL
38	ACCL	1.15 ACCL
47	ACCL	1.15 ACCL
47	ACCL	1.15 ACCL
37.5	ACCL	1.15 ACCL

a)  $-45^\circ$  in XY plane

•PRI DETECTION/ISOLATION PERFORMANCE: SUMMARY

CYCLE	1ST DETECTION	1ST REGULATION
1	38	995
2	36	ACCL
3	375	ACCL
4	375	ACCL
5	37	ACCL
6	38	995
7	365	ACCL
8	37	995
9	37	ACCL
10	365	ACCL
11	375	ACCL
12	37	ACCL
13	37	ACCL
14	365	ACCL
15	375	ACCL
16	37	ACCL
17	365	ACCL
18	375	ACCL
19	37	ACCL
20	365	ACCL
21	375	ACCL
22	37	ACCL
23	365	ACCL
24	375	ACCL
25	37	ACCL
26	365	ACCL
27	375	ACCL
28	37	ACCL
29	365	ACCL
30	375	ACCL
31	37	ACCL
32	365	ACCL
33	375	ACCL
34	37	ACCL
35	365	ACCL
36	375	ACCL
37	37	ACCL
38	365	ACCL
39	375	ACCL
40	37	ACCL
41	365	ACCL
42	375	ACCL
43	37	ACCL
44	365	ACCL
45	375	ACCL
46	37	ACCL
47	365	ACCL
48	375	ACCL
49	37	ACCL
50	365	ACCL
51	375	ACCL
52	37	ACCL
53	365	ACCL
54	375	ACCL
55	37	ACCL
56	365	ACCL
57	375	ACCL
58	37	ACCL
59	365	ACCL
60	375	ACCL
61	37	ACCL
62	365	ACCL
63	375	ACCL
64	37	ACCL
65	365	ACCL
66	375	ACCL
67	37	ACCL
68	365	ACCL
69	375	ACCL
70	37	ACCL
71	365	ACCL
72	375	ACCL
73	37	ACCL
74	365	ACCL
75	375	ACCL
76	37	ACCL
77	365	ACCL
78	375	ACCL
79	37	ACCL
80	365	ACCL
81	375	ACCL
82	37	ACCL
83	365	ACCL
84	375	ACCL
85	37	ACCL
86	365	ACCL
87	375	ACCL
88	37	ACCL
89	365	ACCL
90	375	ACCL
91	37	ACCL
92	365	ACCL
93	375	ACCL
94	37	ACCL
95	365	ACCL
96	375	ACCL
97	37	ACCL
98	365	ACCL
99	375	ACCL
100	37	ACCL
101	365	ACCL
102	375	ACCL
103	37	ACCL
104	365	ACCL
105	375	ACCL
106	37	ACCL
107	365	ACCL
108	375	ACCL
109	37	ACCL
110	365	ACCL
111	375	ACCL
112	37	ACCL
113	365	ACCL
114	375	ACCL
115	37	ACCL
116	365	ACCL
117	375	ACCL
118	37	ACCL
119	365	ACCL
120	375	ACCL
121	37	ACCL
122	365	ACCL
123	375	ACCL
124	37	ACCL
125	365	ACCL
126	375	ACCL
127	37	ACCL
128	365	ACCL
129	375	ACCL
130	37	ACCL
131	365	ACCL
132	375	ACCL
133	37	ACCL
134	365	ACCL
135	375	ACCL
136	37	ACCL
137	365	ACCL
138	375	ACCL
139	37	ACCL
140	365	ACCL
141	375	ACCL
142	37	ACCL
143	365	ACCL
144	375	ACCL
145	37	ACCL
146	365	ACCL
147	375	ACCL
148	37	ACCL
149	365	ACCL
150	375	ACCL

**b) X axis**

## SPORT DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE	1ST DETECTION	1ST ISOLATION
1	5 2	ACCL
2	495	ACCL
3	48	ACCL
4	52	ACCL
5	52	ACCL
6	52	ACCL
7	57	ACCL
8	57	ACCL
9	55	ACCL
10	425	ACCL
11	425	ACCL
12	77	ACCL
13	495	ACCL
14	38	ACCL
15	72	ACCL
16	72	ACCL
17	72	ACCL
18	72	ACCL
19	43	ACCL
20	43	ACCL
21	81	ACCL
22	87	ACCL
23	545	ACCL
24	72	ACCL
25	525	ACCL
26	525	ACCL
27	85	ACCL
28	57	ACCL
29	57	ACCL
30	57	ACCL
31	57	ACCL
32	57	ACCL
33	57	ACCL
34	57	ACCL
35	57	ACCL
36	57	ACCL
37	57	ACCL
38	57	ACCL
39	57	ACCL
40	57	ACCL
41	57	ACCL
42	57	ACCL
43	57	ACCL
44	57	ACCL
45	57	ACCL
46	57	ACCL
47	57	ACCL
48	57	ACCL
49	57	ACCL
50	57	ACCL
51	57	ACCL
52	57	ACCL
53	57	ACCL
54	57	ACCL
55	57	ACCL
56	57	ACCL
57	57	ACCL
58	57	ACCL
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67	57	ACCL
68	57	ACCL
69	57	ACCL
70	57	ACCL
71	57	ACCL
72	57	ACCL
73	57	ACCL
74	57	ACCL
75	57	ACCL
76	57	ACCL
77	57	ACCL
78	57	ACCL
79	57	ACCL
80	57	ACCL
81	57	ACCL
82	57	ACCL
83	57	ACCL
84	57	ACCL
85	57	ACCL
86	57	ACCL
87	57	ACCL
88	57	ACCL
89	57	ACCL
90	57	ACCL
91	57	ACCL
92	57	ACCL
93	57	ACCL
94	57	ACCL
95	57	ACCL
96	57	ACCL
97	57	ACCL
98	57	ACCL
99	57	ACCL
100	57	ACCL

c)  $+45^\circ$  in XY plane

### SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE		1ST DETECTION		1ST ISOLATION	
1	1235	ACCL	177	ACCL	5
2	75	ACCL	1475	ACCL	5
3	97	ACCL	171	ACCL	5
4	125	ACCL	171	ACCL	5
5	125	ACCL	175	ACCL	5
6	125	ACCL			
7	45	ACCL			
8	127	ACCL			
9	135	ACCL			
10	125	ACCL	170	ACCL	5
11	125	ACCL			
12	125	ACCL			
13	125	ACCL			
14	125	ACCL	1475	ACCL	5
15	125	ACCL			
16	125	ACCL			
17	125	ACCL			
18	125	ACCL			
19	125	ACCL			
20	125	ACCL			
21	125	ACCL			
22	125	ACCL			
23	125	ACCL			
24	125	ACCL			
25	125	ACCL			
26	125	ACCL			
27	125	ACCL			
28	125	ACCL			
29	125	ACCL			
30	125	ACCL			
31	125	ACCL			
32	125	ACCL			
33	125	ACCL			
34	125	ACCL			
35	125	ACCL			
36	125	ACCL			
37	125	ACCL			
38	125	ACCL			
39	125	ACCL			
40	125	ACCL			
41	125	ACCL			
42	125	ACCL			
43	125	ACCL			
44	125	ACCL			
45	125	ACCL			
46	125	ACCL			
47	125	ACCL			
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86	125	ACCL			
87	125	ACCL			
88	125	ACCL			
89	125	ACCL			
90	125	ACCL			
91	125	ACCL			
92	125	ACCL			
93	125	ACCL			
94	125	ACCL			
95	125	ACCL			
96	125	ACCL			
97	125	ACCL			
98	125	ACCL			
99	125	ACCL			
100	125	ACCL			
101	125	ACCL			
102	125	ACCL			

**d) Y axis**

## SFRT DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE	TEST DETECTION	TEST ISOLATION
1	69	ACCL
2	67	ACCL
3	76	ACCL
4	85	ACCL
5	94	ACCL
6	103	ACCL
7	112	ACCL
8	121	ACCL
9	130	ACCL
10	139	ACCL
11	148	ACCL
12	157	ACCL
13	166	ACCL
14	175	ACCL
15	184	ACCL
16	193	ACCL
17	202	ACCL
18	211	ACCL
19	220	ACCL
20	229	ACCL
21	238	ACCL
22	247	ACCL
23	256	ACCL
24	265	ACCL
25	274	ACCL
26	283	ACCL
27	292	ACCL
28	301	ACCL
29	310	ACCL
30	319	ACCL
31	328	ACCL
32	337	ACCL
33	346	ACCL
34	355	ACCL
35	364	ACCL
36	373	ACCL
37	382	ACCL
38	391	ACCL
39	400	ACCL
40	409	ACCL
41	418	ACCL
42	427	ACCL
43	436	ACCL
44	445	ACCL
45	454	ACCL
46	463	ACCL
47	472	ACCL
48	481	ACCL
49	490	ACCL
50	499	ACCL
51	508	ACCL
52	517	ACCL
53	526	ACCL
54	535	ACCL
55	544	ACCL
56	553	ACCL
57	562	ACCL
58	571	ACCL
59	580	ACCL
60	589	ACCL
61	598	ACCL
62	607	ACCL
63	616	ACCL
64	625	ACCL
65	634	ACCL
66	643	ACCL
67	652	ACCL
68	661	ACCL
69	670	ACCL
70	679	ACCL
71	688	ACCL
72	697	ACCL
73	706	ACCL
74	715	ACCL
75	724	ACCL
76	733	ACCL
77	742	ACCL
78	751	ACCL
79	760	ACCL
80	769	ACCL
81	778	ACCL
82	787	ACCL
83	796	ACCL
84	805	ACCL
85	814	ACCL
86	823	ACCL
87	832	ACCL
88	841	ACCL
89	850	ACCL
90	859	ACCL
91	868	ACCL
92	877	ACCL
93	886	ACCL
94	895	ACCL
95	904	ACCL
96	913	ACCL
97	922	ACCL
98	931	ACCL
99	940	ACCL
100	949	ACCL
101	958	ACCL
102	967	ACCL
103	976	ACCL
104	985	ACCL
105	994	ACCL
106	1003	ACCL
107	1012	ACCL
108	1021	ACCL
109	1030	ACCL
110	1039	ACCL
111	1048	ACCL
112	1057	ACCL
113	1066	ACCL
114	1075	ACCL
115	1084	ACCL
116	1093	ACCL
117	1102	ACCL
118	1111	ACCL
119	1120	ACCL
120	1129	ACCL
121	1138	ACCL
122	1147	ACCL
123	1156	ACCL
124	1165	ACCL
125	1174	ACCL
126	1183	ACCL
127	1192	ACCL
128	1201	ACCL
129	1210	ACCL
130	1219	ACCL
131	1228	ACCL
132	1237	ACCL
133	1246	ACCL
134	1255	ACCL
135	1264	ACCL
136	1273	ACCL
137	1282	ACCL
138	1291	ACCL
139	1300	ACCL
140	1309	ACCL
141	1318	ACCL
142	1327	ACCL
143	1336	ACCL
144	1345	ACCL
145	1354	ACCL
146	1363	ACCL
147	1372	ACCL

**e) Z axis**

**Table 8. 5000 ppm Accelerometer Scale Factor Error, IMU #1**

ORIGINAL PAGE IS  
OF POOR QUALITY

CYCLE	1ST DETECTION	1ST LOSS-ATTN
1	ACCL	ACCL
2	ACCL	ACCL
3	ACCL	ACCL
4	ACCL	ACCL
5	ACCL	ACCL
6	ACCL	ACCL
7	ACCL	ACCL
8	ACCL	ACCL
9	ACCL	ACCL
10	ACCL	ACCL
11	ACCL	ACCL
12	ACCL	ACCL
13	ACCL	ACCL
14	ACCL	ACCL
15	ACCL	ACCL
16	ACCL	ACCL
17	ACCL	ACCL
18	ACCL	ACCL
19	ACCL	ACCL
20	ACCL	ACCL
21	ACCL	ACCL
22	ACCL	ACCL
23	ACCL	ACCL
24	ACCL	ACCL
25	ACCL	ACCL
26	ACCL	ACCL
27	ACCL	ACCL
28	ACCL	ACCL
29	ACCL	ACCL
30	ACCL	ACCL
31	ACCL	ACCL
32	ACCL	ACCL
33	ACCL	ACCL
34	ACCL	ACCL
35	ACCL	ACCL
36	ACCL	ACCL
37	ACCL	ACCL
38	ACCL	ACCL
39	ACCL	ACCL
40	ACCL	ACCL
41	ACCL	ACCL
42	ACCL	ACCL
43	ACCL	ACCL
44	ACCL	ACCL
45	ACCL	ACCL
46	ACCL	ACCL
47	ACCL	ACCL
48	ACCL	ACCL
49	ACCL	ACCL
50	ACCL	ACCL
51	ACCL	ACCL
52	ACCL	ACCL
53	ACCL	ACCL
54	ACCL	ACCL
55	ACCL	ACCL
56	ACCL	ACCL
57	ACCL	ACCL
58	ACCL	ACCL
59	ACCL	ACCL
60	ACCL	ACCL
61	ACCL	ACCL
62	ACCL	ACCL
63	ACCL	ACCL
64	ACCL	ACCL
65	ACCL	ACCL
66	ACCL	ACCL
67	ACCL	ACCL
68	ACCL	ACCL
69	ACCL	ACCL
70	ACCL	ACCL
71	ACCL	ACCL
72	ACCL	ACCL
73	ACCL	ACCL
74	ACCL	ACCL
75	ACCL	ACCL
76	ACCL	ACCL
77	ACCL	ACCL
78	ACCL	ACCL
79	ACCL	ACCL
80	ACCL	ACCL
81	ACCL	ACCL
82	ACCL	ACCL
83	ACCL	ACCL
84	ACCL	ACCL
85	ACCL	ACCL
86	ACCL	ACCL
87	ACCL	ACCL
88	ACCL	ACCL
89	ACCL	ACCL
90	ACCL	ACCL
91	ACCL	ACCL
92	ACCL	ACCL
93	ACCL	ACCL
94	ACCL	ACCL
95	ACCL	ACCL
96	ACCL	ACCL
97	ACCL	ACCL
98	ACCL	ACCL
99	ACCL	ACCL
100	ACCL	ACCL

a)  $-45^\circ$  in XY plane

SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY					
CYCLE	1ST DETECTION		1ST ISOLATION		
1	01:05	ACCL	1:05	ACCL	1
2	01:05	ACCL	1:05	ACCL	2
3	01:05	ACCL	1:05	ACCL	3
4	01:05	ACCL	1:05	ACCL	4
5	01:05	ACCL	1:05	ACCL	5
6	01:05	ACCL	1:05	ACCL	6
7	01:05	ACCL	1:05	ACCL	7
8	01:05	ACCL	1:05	ACCL	8
9	01:05	ACCL	1:05	ACCL	9
10	01:05	ACCL	1:05	ACCL	10
11	01:05	ACCL	1:05	ACCL	11
12	01:05	ACCL	1:05	ACCL	12
13	01:05	ACCL	1:05	ACCL	13
14	01:05	ACCL	1:05	ACCL	14
15	01:05	ACCL	1:05	ACCL	15
16	01:05	ACCL	1:05	ACCL	16
17	01:05	ACCL	1:05	ACCL	17
18	01:05	ACCL	1:05	ACCL	18
19	01:05	ACCL	1:05	ACCL	19
20	01:05	ACCL	1:05	ACCL	20
21	01:05	ACCL	1:05	ACCL	21
22	01:05	ACCL	1:05	ACCL	22
23	01:05	ACCL	1:05	ACCL	23
24	01:05	ACCL	1:05	ACCL	24
25	01:05	ACCL	1:05	ACCL	25
26	01:05	ACCL	1:05	ACCL	26
27	01:05	ACCL	1:05	ACCL	27
28	01:05	ACCL	1:05	ACCL	28
29	01:05	ACCL	1:05	ACCL	29
30	01:05	ACCL	1:05	ACCL	30
31	01:05	ACCL	1:05	ACCL	31
32	01:05	ACCL	1:05	ACCL	32
33	01:05	ACCL	1:05	ACCL	33
34	01:05	ACCL	1:05	ACCL	34
35	01:05	ACCL	1:05	ACCL	35
36	01:05	ACCL	1:05	ACCL	36
37	01:05	ACCL	1:05	ACCL	37
38	01:05	ACCL	1:05	ACCL	38
39	01:05	ACCL	1:05	ACCL	39
40	01:05	ACCL	1:05	ACCL	40
41	01:05	ACCL	1:05	ACCL	41
42	01:05	ACCL	1:05	ACCL	42
43	01:05	ACCL	1:05	ACCL	43
44	01:05	ACCL	1:05	ACCL	44
45	01:05	ACCL	1:05	ACCL	45
46	01:05	ACCL	1:05	ACCL	46
47	01:05	ACCL	1:05	ACCL	47
48	01:05	ACCL	1:05	ACCL	48
49	01:05	ACCL	1:05	ACCL	49
50	01:05	ACCL	1:05	ACCL	50
51	01:05	ACCL	1:05	ACCL	51
52	01:05	ACCL	1:05	ACCL	52
53	01:05	ACCL	1:05	ACCL	53
54	01:05	ACCL	1:05	ACCL	54
55	01:05	ACCL	1:05	ACCL	55
56	01:05	ACCL	1:05	ACCL	56
57	01:05	ACCL	1:05	ACCL	57
58	01:05	ACCL	1:05	ACCL	58
59	01:05	ACCL	1:05	ACCL	59
60	01:05	ACCL	1:05	ACCL	60
61	01:05	ACCL	1:05	ACCL	61
62	01:05	ACCL	1:05	ACCL	62
63	01:05	ACCL	1:05	ACCL	63
64	01:05	ACCL	1:05	ACCL	64
65	01:05	ACCL	1:05	ACCL	65
66	01:05	ACCL	1:05	ACCL	66
67	01:05	ACCL	1:05	ACCL	67
68	01:05	ACCL	1:05	ACCL	68
69	01:05	ACCL	1:05	ACCL	69
70	01:05	ACCL	1:05	ACCL	70
71	01:05	ACCL	1:05	ACCL	71
72	01:05	ACCL	1:05	ACCL	72
73	01:05	ACCL	1:05	ACCL	73
74	01:05	ACCL	1:05	ACCL	74
75	01:05	ACCL	1:05	ACCL	75
76	01:05	ACCL	1:05	ACCL	76
77	01:05	ACCL	1:05	ACCL	77
78	01:05	ACCL	1:05	ACCL	78
79	01:05	ACCL	1:05	ACCL	79
80	01:05	ACCL	1:05	ACCL	80
81	01:05	ACCL	1:05	ACCL	81
82	01:05	ACCL	1:05	ACCL	82
83	01:05	ACCL	1:05	ACCL	83
84	01:05	ACCL	1:05	ACCL	84
85	01:05	ACCL	1:05	ACCL	85
86	01:05	ACCL	1:05	ACCL	86
87	01:05	ACCL	1:05	ACCL	87
88	01:05	ACCL	1:05	ACCL	88
89	01:05	ACCL	1:05	ACCL	89
90	01:05	ACCL	1:05	ACCL	90
91	01:05	ACCL	1:05	ACCL	91
92	01:05	ACCL	1:05	ACCL	92
93	01:05	ACCL	1:05	ACCL	93
94	01:05	ACCL	1:05	ACCL	94
95	01:05	ACCL	1:05	ACCL	95
96	01:05	ACCL	1:05	ACCL	96
97	01:05	ACCL	1:05	ACCL	97
98	01:05	ACCL	1:05	ACCL	98
99	01:05	ACCL	1:05	ACCL	99
100	01:05	ACCL	1:05	ACCL	100
12064		23435			

**b) X axis**

SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY				
CYCLE	1ST DETECTION			1ST ISOLATION
1	100	100	100	100
2	100	100	100	100
3	100	100	100	100
4	100	100	100	100
5	100	100	100	100
6	100	100	100	100
7	100	100	100	100
8	100	100	100	100
9	100	100	100	100
10	100	100	100	100
11	100	100	100	100
12	100	100	100	100
13	100	100	100	100
14	100	100	100	100
15	100	100	100	100
16	100	100	100	100
17	100	100	100	100
18	100	100	100	100
19	100	100	100	100
20	100	100	100	100
21	100	100	100	100
22	100	100	100	100
23	100	100	100	100
24	100	100	100	100
25	100	100	100	100
26	100	100	100	100
27	100	100	100	100
28	100	100	100	100
29	100	100	100	100
30	100	100	100	100
31	100	100	100	100
32	100	100	100	100
33	100	100	100	100
34	100	100	100	100
35	100	100	100	100
36	100	100	100	100
37	100	100	100	100
38	100	100	100	100
39	100	100	100	100
40	100	100	100	100
41	100	100	100	100
42	100	100	100	100
43	100	100	100	100
44	100	100	100	100
45	100	100	100	100
46	100	100	100	100
47	100	100	100	100
48	100	100	100	100
49	100	100	100	100
50	100	100	100	100
51	100	100	100	100
52	100	100	100	100
53	100	100	100	100
54	100	100	100	100
55	100	100	100	100
56	100	100	100	100
57	100	100	100	100
58	100	100	100	100
59	100	100	100	100
60	100	100	100	100
61	100	100	100	100
62	100	100	100	100
63	100	100	100	100
64	100	100	100	100
65	100	100	100	100
66	100	100	100	100
67	100	100	100	100
68	100	100	100	100
69	100	100	100	100
70	100	100	100	100
71	100	100	100	100
72	100	100	100	100
73	100	100	100	100
74	100	100	100	100
75	100	100	100	100
76	100	100	100	100
77	100	100	100	100
78	100	100	100	100
79	100	100	100	100
80	100	100	100	100
81	100	100	100	100
82	100	100	100	100
83	100	100	100	100
84	100	100	100	100
85	100	100	100	100
86	100	100	100	100
87	100	100	100	100
88	100	100	100	100
89	100	100	100	100
90	100	100	100	100
91	100	100	100	100
92	100	100	100	100
93	100	100	100	100
94	100	100	100	100
95	100	100	100	100
96	100	100	100	100
97	100	100	100	100
98	100	100	100	100
99	100	100	100	100
100	100	100	100	100

- c)  $+45^\circ$  in XY plane

SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY			
CYCLE	1ST DETECTION	1ST ISOLATION	
1			
2			
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96			
97			
98			
99			
100			

d) Y axis

[illegible]

e) Z axis

**Table 9. 8000 ppm Accelerometer Scale Factor Error, IMU #1**

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SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE	1ST-DETECTION	1ST-ISOLATION
1	0	0
2	0	0
3	0	0
4	0	0
5	0	0
6	0	0
7	0	0
8	0	0
9	0	0
10	0	0
11	0	0
12	0	0
13	0	0
14	0	0
15	0	0
16	0	0
17	0	0
18	0	0
19	0	0
20	0	0
21	0	0
22	0	0
23	0	0
24	0	0
25	0	0
26	0	0
27	0	0
28	0	0
29	0	0
30	0	0
31	0	0
32	0	0
33	0	0
34	0	0
35	0	0
36	0	0
37	0	0
38	0	0
39	0	0
40	0	0
41	0	0
42	0	0
43	0	0
44	0	0
45	0	0
46	0	0
47	0	0
48	0	0
49	0	0
50	0	0
51	0	0
52	0	0
53	0	0
54	0	0
55	0	0
56	0	0
57	0	0
58	0	0
59	0	0
60	0	0
61	0	0
62	0	0
63	0	0
64	0	0
65	0	0
66	0	0
67	0	0
68	0	0
69	0	0
70	0	0
71	0	0
72	0	0
73	0	0
74	0	0
75	0	0
76	0	0
77	0	0
78	0	0
79	0	0
80	0	0
81	0	0
82	0	0
83	0	0
84	0	0
85	0	0
86	0	0
87	0	0
88	0	0
89	0	0
90	0	0
91	0	0
92	0	0
93	0	0
94	0	0
95	0	0
96	0	0
97	0	0
98	0	0
99	0	0
100	0	0

Table 10. Nominal IPU's #1 and #2